



Figure 1. Location of LDNR Vegetation stations sampled after Hurricane Rita. Stations were classified according to storm induced stress as described in Table 1.

METHODS

In response to Hurricane Rita in 2005, over 300 LDNR vegetation stations were sampled. Of those, 163 stations in emergent marsh were sampled in the late summer/early fall of 2006 (the rest were on terraces). The stations represented a subset of the LDNR vegetation stations established on the Chenier Plain to monitor CWPRA projects including CS-20 (40 stations), CS-17 (24 stations), CS-31 (30 stations), CS-28 (18 stations), ME-04 (18 stations), ME-11 (12 stations) (Figure 1).

After the 2005 data collection, the stations were classified according to the level of disturbance/stress they had experienced and the resulting vegetation response. Stations were classified as either Open water, Severely Stressed, Moderately Stressed, or Slightly Stressed (Table 1). Data collected in 2006 and the last CWPRA data available from prior to Hurricane Rita were also classified by stress.

At each station, a marker had been previously established. A 2m x 2m square was placed on the marsh and Total % Cover, % Cover of each species present in the plot, and height of the dominant species was collected. Presence of other species that were not in the plot, depth of surface water, salinity, and porewater salinity was noted.

The compiled vegetation data from the three sampling periods were also utilized to classify each site according to Visser's vegetation types of the Chenier Plain (Visser et al., 2000). The data were analyzed to determine the impact of the storm on Total % Cover and Species Richness at three levels; overall (all 163 stations), by CWPRA restoration project (7 projects), and with Visser vegetation type (6 types).

RESULTS

Stress and Recovery

Prior to Hurricane Rita, most of the vegetation stations utilized for this survey were healthy and intact (>80%). Following the hurricane in 2005, most of the stations were stressed (67%) or worse (20%). A year later in 2006, over 50% of the stations were back to pre storm stress levels. Severely stressed stations either converted to open water or recovered to a less stressed state. Most stations that had been converted to open water in 2005 did not recover (Figures 1 and 2).

Total % Cover and Species Richness

ANOVA was utilized to test for differences in Total % Cover (% of plot covered by living vegetation) and Species Richness (n species per plot) over the three sampling periods, by CWPRA Project, and with Visser Veg Type classifications.

Overall

Total % Cover was significantly different over time (Figure 3). Post ANOVA comparisons (Tukey's HSD) revealed that all three sampling periods were significantly different meaning Total % Cover for 2006 is still significantly lower than Pre-Rita levels. Species Richness was also significantly different over the three sampling periods (Figure 4). The number of species present before Rita and in 2006 were statistically the same.

by CWPRA Project

Most of the projects had significant differences over time for both Total % Cover and Species Richness with trends similar to the overall model (Figures 3 and 4). Post ANOVA comparisons were utilized to determine whether the projects had recovered to pre-storm levels for both Cover and Richness (Table 2).

with Visser Veg Type

Visser Veg Type was added to the overall model and the interaction between Visser Type and time was analyzed. Both models had significant differences in Visser Veg Type over time (Figures 5 and 6). Post ANOVA contrasts of Cover and Richness Pre-Rita and Post 06 for each Veg Type revealed that all Visser Types were the same in Total Cover (had recovered to pre-storm levels) and in Richness except Fresh Bulltongue (mostly in the ME-04 project area) which had not recovered and in Oligohaline Wiregrass which had significantly more species per plot post Rita than before (up from 2.83 to 3.22 species).

Table 1. Vegetation Stress Classifications used in this survey.

Vegetation Stress Classification	Description
Open Water	Vegetation has been ripped out. 100% of plot is open water.
Severely stressed	>50% of plot is open water. Vegetation is weak.
Stressed	Perennial grasses and herbs are mostly dead (>50%) or >25% open water. Often dominated by annual shrubs.
Slightly stressed	Perennial grasses are healthy and vigorous.

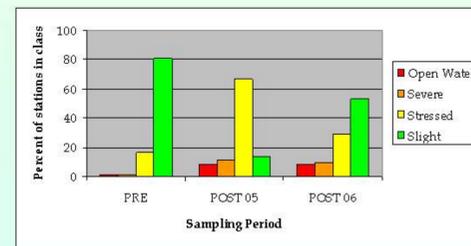


Figure 2. Percent of LDNR Veg stations in each stress class before and after Hurricane Rita.

Table 2. CWPRA Project ANOVA Results

Results of Post ANOVA comparisons by CWPRA Project Summary of 2006 levels relative to Pre Rita and 2005		
Project	Total % Cover	Species Richness*
CS-17	Not Recovered.	Recovered.
CS-20	Not Recovered.	Recovered.
CS-21	Recovered.	Recovered.
CS-28	Recovered.	No Rita Impact.
CS-31	Recovered.	Recovered.
ME-04	Recovered.	Recovered.
ME-11	No Rita Impact.	Recovered.

*Although the number of species present returned to Pre-Rita levels at most projects, many of the species present were disturbance species.

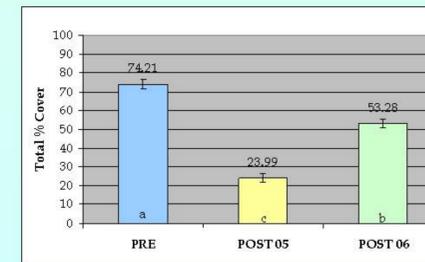


Figure 3. Total % Cover Pre and Post Hurricane Rita. LS Mean ± SE, n=163 stations, F_{2, 162}=109.7, p<0.0001. Levels not connected by same letter are significantly different.

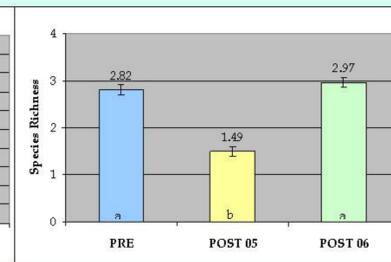


Figure 4. Species Richness Pre and Post Rita. LS Mean ± SE, n=163 stations, F_{2, 162}=56.3, p<0.0001. Levels not connected by same letter are significantly different.

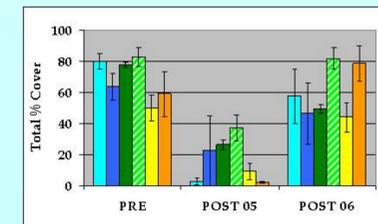


Figure 5. Total % Cover by Visser Veg Type.. LS Mean ± SE, n=163 stations, F_{17, 146}=17.0, p<0.0001.

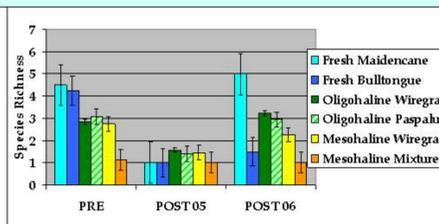


Figure 6. Species Richness by Visser Veg Type. LS Mean ± SE, n=163 stations, F_{17, 146}=10.9, p<0.0001.

DISCUSSION and CONCLUSIONS

Most sites are still in recovery and transition from stressors introduced by Hurricane Rita including prolonged elevated water levels for weeks following the storm, and elevated water and soil salinity which persists today in most areas. Total % Cover and Species Richness have recovered at most projects. The species that compose Cover and Richness are often disturbance species.



Figures 7 and 8. Fresh Bulltongue succession at an ME-04 vegetation station.

General Vegetation Trends:

- Increase in cover and occurrence of salt tolerant species and a decrease in fresh species in all project areas.
- Increase in opportunistic annual species on bare ground in all marsh types.
- Increase in *Paspalum* sp. cover on bare ground in all marsh types.

Species Level Trends in Visser Vegetation Classes:

- Fresh Maidencane - shift from *Panicum hemitomom* dominant to *Echinochloa walterii* and *Cyperus* spp.
- Fresh Bulltongue - shift from *Sagittaria lancifolia* dominant to *Echinochloa walterii* and *Cyperus* spp (Figures 7 and 8).
- Oligohaline Wiregrass - increase in cover of salt tolerant disturbance species and annual shrubs (*Amaranthus australis* and *Iva frutescens*). Areas of dead *Spartina patens* colonized by *Paspalum vaginatum*.
- Mesohaline Wiregrass - increase in % Cover of *Schoenoplectus americanus* and *S. robustus*.
- Mesohaline Mixture - *Distichlis spicata* and *Juncus roemerianus* in recovery.